CO_2 Laser Frequency Multiplication

Report for February 1992

Contract No. 00014-91-C-2279

TEXTRON DEFENSE SYSTEMS

This month has seen increased second harmonic conversion efficiency, with a highest total energy conversion of 70%. The increased sensitivity of phase matching at high conversions was observed. The thermal conductivity of $AgGaSe_2$ was measured. The second harmonic conversion efficiency has been modeled and an experimental threshold for optical coating/surface damage has been obtained.

All of the harmonic generation experiments were performed with the grating-tuned oscillator heavily modulated (depth 1.0) to yield 1.0 nsec pulses at 9.55 μm (spaced by 40 nsec). The gain switched "spike" which contained about 10 pulses was isolated by reduction of the intracavity iris to a diameter of 0.96 cm, considerably below the 1.4 cm diameter needed for transverse mode selection, introducing sufficient loss to reject the pulse "tail" of 2 μsec duration. The short pulse train was expanded and then directed off a converging mirror into the 80 cm amplifier gain length. At the exit the $1/e^2$ spot radius was 0.25 cm and the $AgGaSe_2$ crystal was exposed to fluences up to 1.7 J/cm^{-2}. Harmonic conversion efficiency up to 60% was measured in one run which has been used for modeling purposes, in which the maximum harmonic energy was 80 mJ. The peak intensity in the highest pulse of the most energetic pulse train was 170 MW cm^{-2}. At this level, surface damage appeared simultaneously on entry and exit faces on the third shot. Several tens of pulses were taken without damage at 80% of this intensity (or energy).

The increased sensitivity of the phase matching angle at high conversion was measured. This amounted to almost a factor of two reduction in the angular width for 56% energy conversion - a significant factor in the design of repetition-rate systems.

The thermal conductivity of $AgGaSe_2$ was measured to be 0.013 W cm^{-1} $°C^{-1}$ by a simple technique involving the exponential approach to equilibrium of a 99.8 g copper mass connected via the crystal to a heat stage subject to a temperature jump or drop. This value of conductivity is akin to that of glasses such as pyrex or fused silica, and is a limiting factor on the use of $AgGaSe_2$ in the presence of high optical absorptions.

In the coming month, the pulse duration measurement, which is uncertain because of proximity to the detector and oscilloscope bandwidth limits, will be inproved using the second harmonic autocorrelation technique. For convenience, the same doubling process will again be used, but the interacting beams will interact at a low angle in order to remove fluctuations due to Michelson fringes. This technique should result in a duration measurement accurate to about 0.1 nsec.

Also in March, the conversion of longer pulse trains will be again studied, this time at higher fluence, in order to probe the damage threshold in this case. Lastly, the implications of our measurements for high average power harmonic generation will be studied.